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Observations of glacier mass changes and their system inherent drivers over Western Himalaya (Himachal Pradesh, India) during 2000-2013 using TanDEM-X and SRTM-C DEMs

Saurabh Vijay and Matthias Braun
Institute of Geography, University of Erlangen-Nuremberg, Erlangen, Germany (saurabh.vijay@fau.de)

The glaciers in Himachal Pradesh (HP), India (Western Himalaya) are a part of widely spread Hindu Kush-Karakoram-Himalaya mountain ranges. The glacier mass changes depend on system inherent (size, topography, aspect etc.) and climatic factors (precipitation, temperature etc.). The glaciers in this region are mostly debris-covered with supraglacial ponds. They are mostly land-terminating but few of them terminate at the lakes. The two different precipitation regimes namely, Indian summer monsoon and mid-latitude winter westerlies, influence the glaciers in the region. The continuous observations of such glacier changes using field experiments are often limited and repeat pass satellite data potentially fills this gap.

Previous studies notified that the bench mark glacier, called Chhota Shigri Glacier, experienced a transition from mass gain (or equilibrium) to loss around 1999. This study aims to estimate the mass change of glaciers in HP at two different time scales. During 2000-2012, we subtract TanDEM-X DEMs of Feb, 2012 from the SRTM C/X band DEM of Feb, 2000. The published ice thickness change of Chhota Shigri Glacier from field observations is compared with ice thickness change derived from DEM differencing. This potentially estimates the bias in thickness change due to different radar frequencies (C band for SRTM, X band for TanDEM-X). For 2012-2013, we use repeat pass TanDEM-X DEMs which don't require any further bias correction.

We perform hypsometry analysis (25 m elevation bin) of thickness change of ~800 km2 of ice covered area during these times scales. The analysis shows a transition of thickness change -2.0 myr-1 (4000-4200 m elevation) to -2.7 myr-1 at higher elevations (4200-4800) and further transits upstream. This clearly shows that the presence of thick debris at the glacier tongue act as insulator and reduce the downwasting. The downwasting increases as the surface consists of thin debris and exposed more to radiation. The downwasting linearly decreases further upstream (>4800 m) because of low surface temperatures.

The similar transition of low to high thickness change at/nearby terminus of Chhota Shigri Glacier is observed, which is not much covered by debris (3.4 %). We attribute this to the orientation (absolute North) of the glacier and the presence of high ridges at the glacier tongue which majorly block the solar radiation to reach its surface.

The rapid glacier downwasting is observed at Samudra Tapu Glacier, which consists of debris and supraglacial ponds. The glacier surface, orients to East, is exposed to solar radiation considerably. These system immanent factors cause the glacier to change intensively. We also study such factors for other glaciers, namely Bara Shigri, Parbati, Patsio and Hamtah, in the region. This enables us to extensively study system immanent factors of individual glaciers in the region, in addition to regional mass changes.